REMARKS

Responsive to the Official Action dated November 29, 2002, applicants respectfully request reconsideration of the application in view of the foregoing amendment to independent claim 1. The proposed amendment does not create any new issues or require any additional search by the Examiner, and thus applicants submit that the amendment should be entered. Applicants also believe that the proposed amendment renders all pending claims allowable over the cited art for the reasons discussed below.

In essence, applicants submit that the Examiner has incorrectly assumed that two very different coating techniques (electron beam physical vapor deposition and dense vertically cracked deposition) will produce the same end properties in a ceramic coating. As detailed below, that assumption is not justified in view of the express teachings of the cited patents and other prior art teachings of record. Applicants also believe that the Examiner has improperly combined selected teachings in the patents cited in the November 29 Official Action without any suggestion that such a combination would result in the improved physical properties achieved by applicants' invention.

In the past, persons skilled in the art knew to use zirconia (ZrO_2) that is partially or fully stabilized by yttria (Y_2O_3) or other oxides as the primary constituent of the ceramic layer. The present application explains that stabilization with yttria serves to prevent zirconia from undergoing a tetragonal to monoclinic phase transformation at about 1,000°C that would otherwise result in detrimental volume expansion and eventual coating failure. As the Examiner has observed, yttria-stabilized zirconia has previously been used as the ceramic layer for thermal bond coatings because it exhibits favorable

thermal cycle fatigue properties. However, since the mid-1980s, conventional practice in the art has been to "partially stabilize" zirconia with at least 6-8 weight % yttria. Typical of that accepted teaching is U.S. Patent No. 4,485,151 to Stecura, cited in applicants' specification, which concludes that 6-8 weight % yttria stabilized zirconia should be used when the coating was applied using air plasma spraying. The Stecura '151 patent, like many other prior art references, also teaches against using lower threshold amounts of yttria because the zirconia is only "partially" stabilized, thereby providing an optimum mixture of cubic, tetragonal and monoclinic phases of coating material.

Thus, historically, persons skilled in the art considered the 6-8 percent level of yttria recommended by Stecura as the lowest effective amount that would produce an acceptable coating capable of demonstrating sufficient spallation resistance under the extreme operating conditions of gas turbine engines. More recently, an improved thermal ceramic layer for use in hostile thermal environments was developed by The General Electric Company formed from zirconia stabilized by yttria. Commonly assigned U.S. Patent No. 5,981,088 mentioned in applicants' specification and cited by the Examiner discloses using about 2 to 5% by weight yttria to stabilize the zirconia, but with the coating being deposited on the substrate using electron beam physical vapor deposition ("EBPVP").

Significantly, the present application does not involve the use of yttria-stabilized zirconia using the EBPVP deposition technique described in the '088 patent (and other prior art of record). Instead, the invention relates specifically to the dense vertically cracked ("DVC") deposition of a ceramic layer. Contrary to the Examiner's assumption,

the two deposition techniques are not equivalent and do not result in coatings having the same physical properties, particularly coatings using a lower threshold amount of yttria-stabilized zirconia, *i.e.*, less than 6%.

Indeed, the prior art expressly teaches that the best resistance to thermal cycling using a DVC process requires that the coating contain at least 6% yttria-stabilized zirconia. *See, e.g.,* U.S. Patent No. 5,830,586 to Gray et al (recommending 8% yttria by weight and the balance zirconia, col. 2, line 2); No. 6,432,487 to Graham et al (requiring 6-8 wt % yttria with the balance zirconia, col. 2, lines 37-40; and No. 5,073,433 to Taylor (6 to 8% yttria with the balance zirconia, col. 4, lines 44-45). Persons skilled in the art also recognized that partially stabilized zirconia coatings with higher amounts of yttria – that is, above 6wt % up to about 9 wt% -- avoid the monoclinic phase transformations that otherwise result in less favorable physical properties. *See, e.g.*, Thomas A. Taylor, *"Testing of Stability and Thermal Properties of Thermal Barrier Coatings,"* 1994 ASM Handbook, Vol. 5 at p. 656 (discussing the anticipated lower shock resistance; copy attached). Thus, for many years, persons skilled in the art have cautioned against using lower amounts of yttria, particularly in DVC coatings, because amounts below the 6% level tended to destabilize the structure and hurt the overall coating performance in thermal cycling.

In addition, the scientific community has criticized and recommended against using lower levels of yttria in zirconia because of the resulting larger amount of monoclinic zirconia in the coating phase transformations. *See* the attached Taylor article. Certainly no one skilled in the art of thermal barrier coatings previously recognized that

the use of such a monoclinic phase could produce better erosion resistance. Further, no prior art reference known to applicants predicts that coatings formed with DVC using such low amounts of yttria-stabilized zirconia would actually improve the thermal cycling properties of the resulting coating.

Surprisingly, applicants have found that an improved thermal insulating ceramic layer can be formed of zirconia that has been partially stabilized by yttria in the amount substantially lower than anything predicted by Stecura or the other prior art cited by the Examiner. Perhaps even more significant, applicants discovered that the yttria-stabilized zirconia could be applied using a dense vertically cracked deposition process which transformed the ceramic into a tetragonal crystal structure that tended to resist volume changes during repeated thermal cycling. The stabilized transformation also toughens the zirconia when mechanical stresses are applied. To applicants' knowledge, those improved physical properties have never been predicted or practiced in the prior art.

Turning to the Examiner's specific rejections under Section 103, the '088 patent to Bruce relies on an electron beam physical vapor deposition technique – not DVC -- to form the ceramic topcoat (noting the advantages achieved by the resulting strain-tolerant columnar grain structure). Although Bruce contemplates using lower amounts of yttria-stabilized zirconia as the examiner noted, Bruce does not account for the inevitable structural differences in the coating that results from the use of a DVC deposition process, as opposed to EBPVD. Bruce simply did not recognize or predict the improved particle erosion resistance resulting from a dense vertically cracked ceramic layer using low threshold amount of yttria-stabilized Zirconia. Nor would that prediction be

reasonable given the consistent teachings in the art against using higher amounts of yttria-stabilized zirconia with DVC.

Nor can Bruce '088 be combined with the '539 patent to Farmer. Farmer does refer to the use of a dense vertically cracked deposition technique. However, the patent repeatedly teaches that the amount of yttria should be much higher -- at least 8% by weight. *See* col. 3, line 56. That higher weight percentage is not surprising given the consistent teaching in the art that yttria amounts below 6% tend to destabilize the coating structure, reduce thermal strain resistance over time actually and jeopardize the coating performance in applications involving severe thermal cycling. The '539 patent to Farmer does disclose using a DVC process to increase thermal resistance strain. However, Farmer also teaches that in order to achieve that improved result with DVC, a skilled artisan must use coatings having much higher amounts of yttria-stabilized zirconia.

Finally, applicants submit that the combination of the '898 Burns et al patent with Bruce '088 or Farmer '539 does not render applicants' claimed thermal barrier coatings obvious. Burns et al describe using a mixture of zirconium oxide and about 3-25% yttrium oxide (or other stabilizers). That extremely wide range of stabilizers certainly would not lead someone skilled in the art to select less than 6% by weight yttria, particularly in combination with a DVC deposition technique. If anything, the patent suggests that the best physical properties can be achieved using levels of yttria-stabilized zirconia well above 6% by weight. *See* col. 4, lines 57-60. Again, Burns et al merely underscore applicants' novel approach of using a dense vertically cracked deposition

technique in combination with much lower threshold amounts of yttria to achieve improved physical properties than the art believed would be possible.

For all the foregoing reasons, applicants respectfully submit that the Examiner's 103 rejections should be withdrawn and amended claims 9-12 be entered and allowed.

Respectfully submitted,

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